

LESSONS LEARNED FROM PREVIOUS LARGE PROCUREMENTS OF SCIENTIFIC CCDs

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- **SAO Megacam – successful purchase of 40 large (2K X 4.5K) imagers.**
- **The failed FAME procurement – 44 large flight CCDs, plus engineering units.**
- **The successful (so far) Kepler program – 60 large flight CCDs, plus engineering units.**

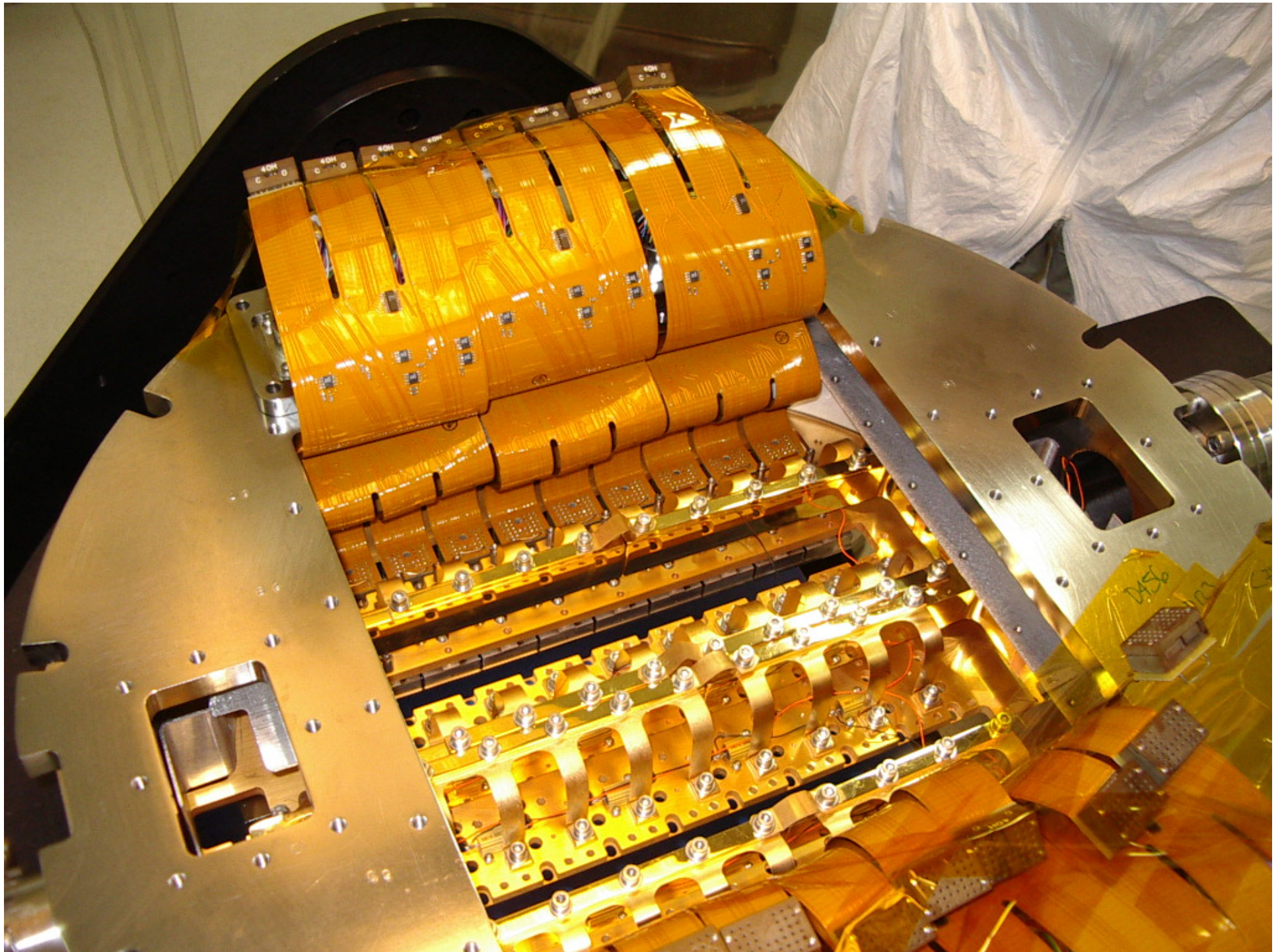
SAO MEGACAM

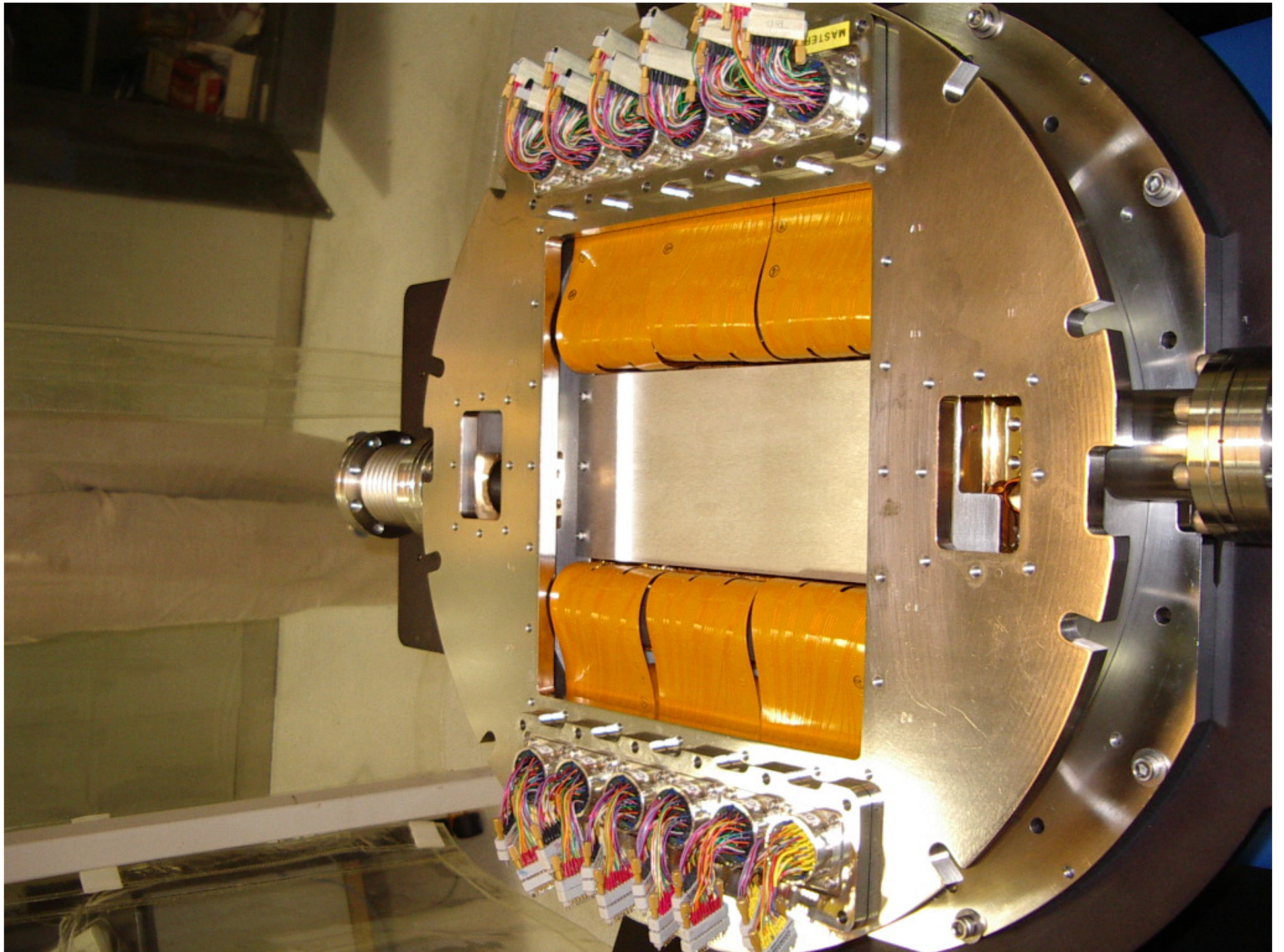
- **36 science CCDs, each 2K X 4.5K, plus 2 guider CCDs.**
- **18K X 18K = 324 Mpixels**
- **72 science video channels.**
- **modest 200 kHz readout rate.**
- **interface over a single optical fiber link.**



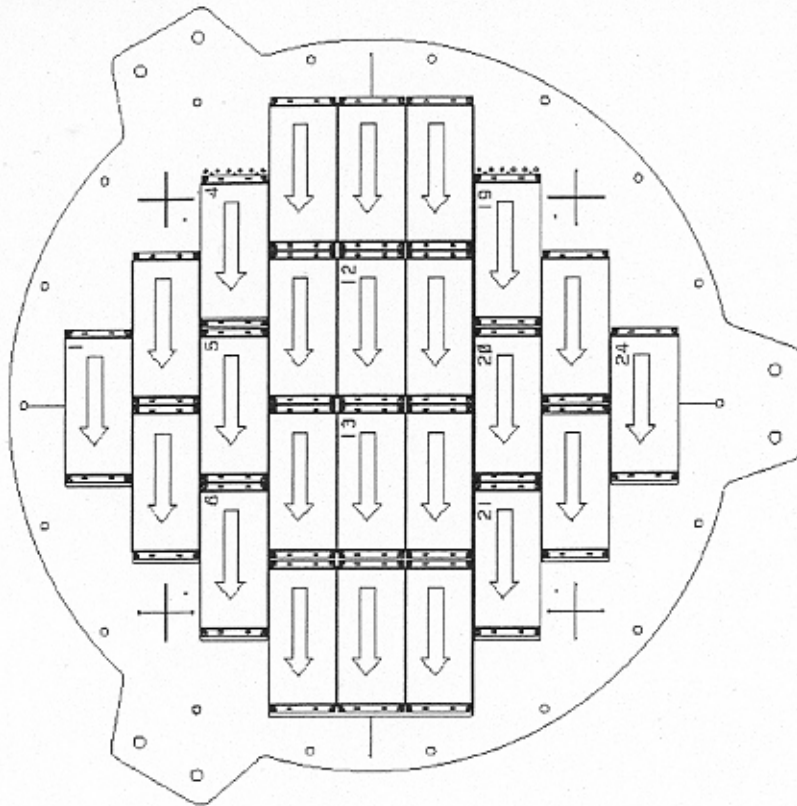
SAO Megacam CCD procurement

- **EEV-Marconi-E2V supplier**
- **40 devices delivered over 2.5 years**
- **not a strain on capacity**
- **vendor testing verified, no further acceptance testing**
- **only one disappointment – unreliable ZIF connection**





The FAME Focal Plain – Before Descope



- The focal plane is comprised of 24 2Kx4K CCDs which are maintained at -80C by a large radiator mounted on-top of the instrument
- Stars in the two fields-of-view are overlaid on a single focal plane containing 24 CCDs
- All CCDs in the FPA are clocked synchronously in TDI mode

The FAME Debacle

- **Procurement: 2 evaluation, 10 engineering, 44 flight CCDs.**
- **Mission was cancelled primarily due to gross underestimates of cost and difficulty.**
- **Major technical failure – vendor supplied no working engineering or flight parts in 18 months of trying. Approx. \$1.5M of \$2.6M budget spent.**
- **Management failed to turn on a second source until too late to rescue the mission, even if the costs had been under better control.**
- **Sensitized NASA to the risks of single-source procurement of critical items such as CCDs.**

The Kepler CCD Procurement

- **Single vendor approach now avoided to reduce risk.**
- **Two vendors contracted for (nearly) identical devices (30 each, plus engineering devices).**
- **Mission prepared to fly both types if successfully produced.**
- **Packaging supplied by mission to the vendors.**

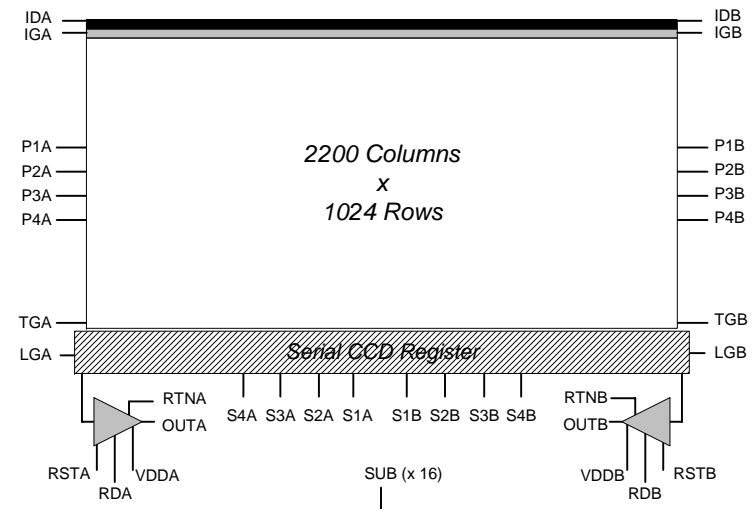
CCD Overview

Kepler CCDs Readily Manufacturable

- *Kepler* needs 42 science CCDs
 - 2,200 column x 1,024 row full frame CCDs
 - Pixel pitch is $27\text{ }\mu\text{m} \times 27\text{ }\mu\text{m}$
 - 20 light-shielded rows adjacent to serial CCD for smear and dark offset
 - 3 Mpixel/s pixel rates, 2.8 s integration periods
 - FPA FOV > 100 sq. deg. (113 w/ vignetting)
 - Several CCD vendors already producing similar size and quality CCDs in *Kepler* quantities

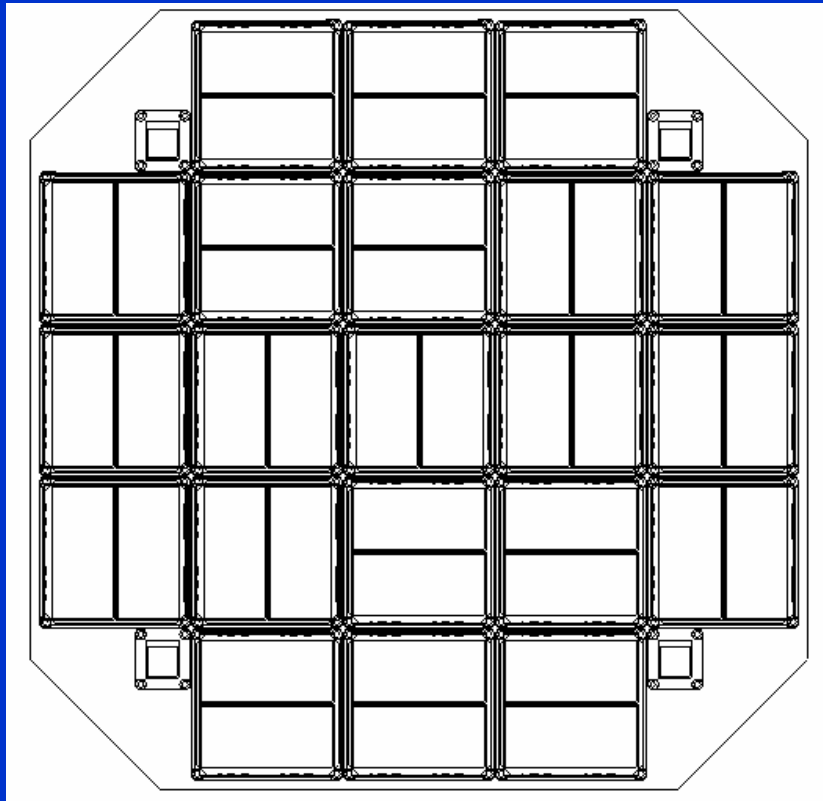


Kepler Science CCD



FPA - Mechanical System

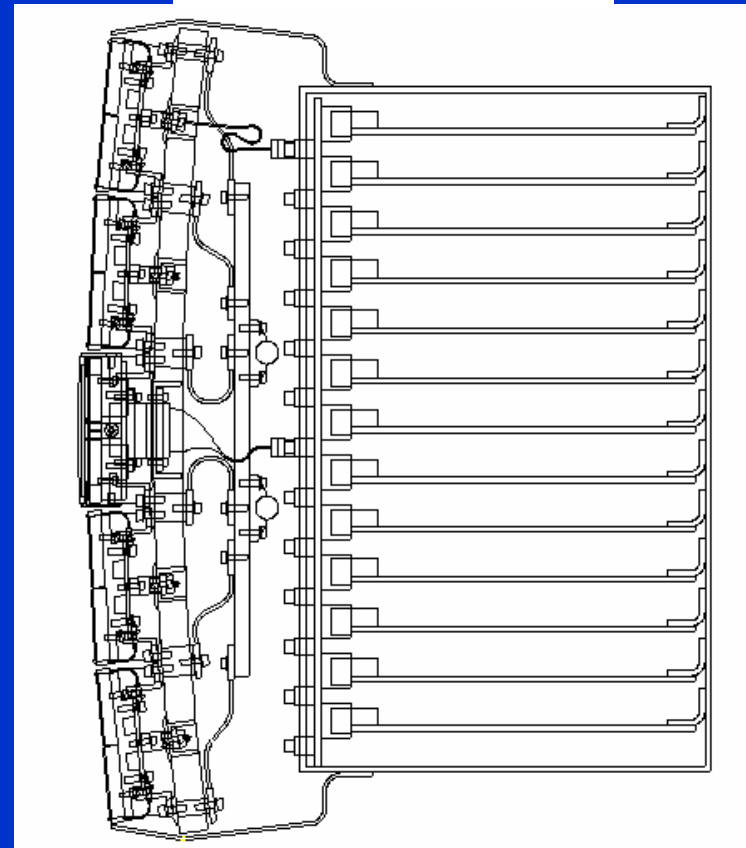
21 CCD modules are arranged in a rotationally symmetric configuration to support the 90° roll maneuver every 3 months



Top View of FPA

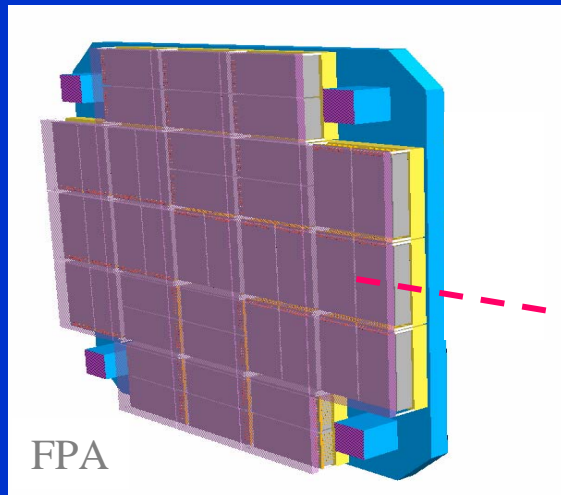
Due to 90° rolls, a single module failure will impact 19% ($4 \div 21$) of the FPA

Side View of FPA/FPI



Only one CCD module is shown with attached lens in the above figure

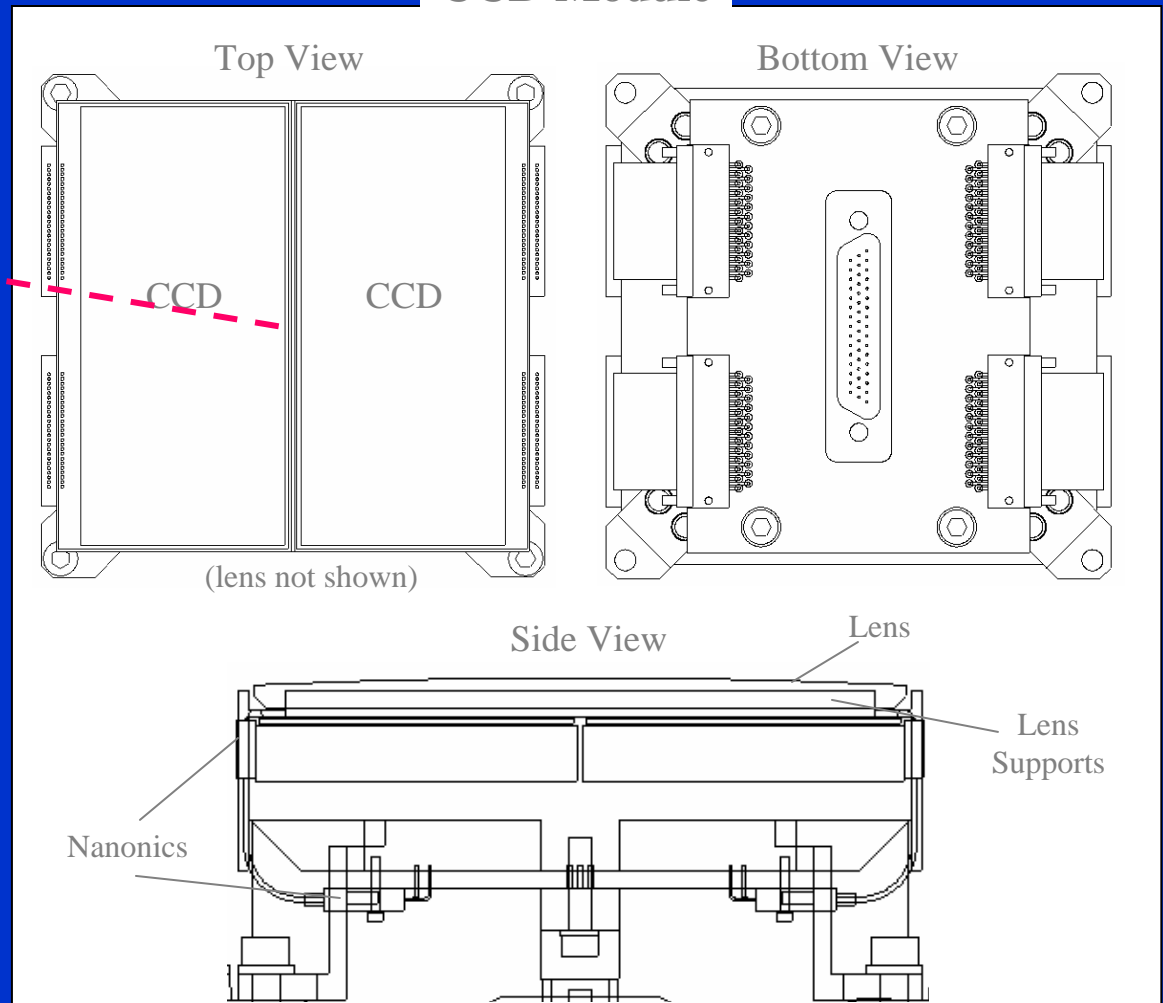
FPA - Mechanical System



Each CCD module contains 2 CCDs (built up from 2 Detector Chip Assemblies (DCAs))

Two handles (not shown here) can be attached to the top surface of the CCD module to ease the handling and mate/de-mate tasks

CCD Module

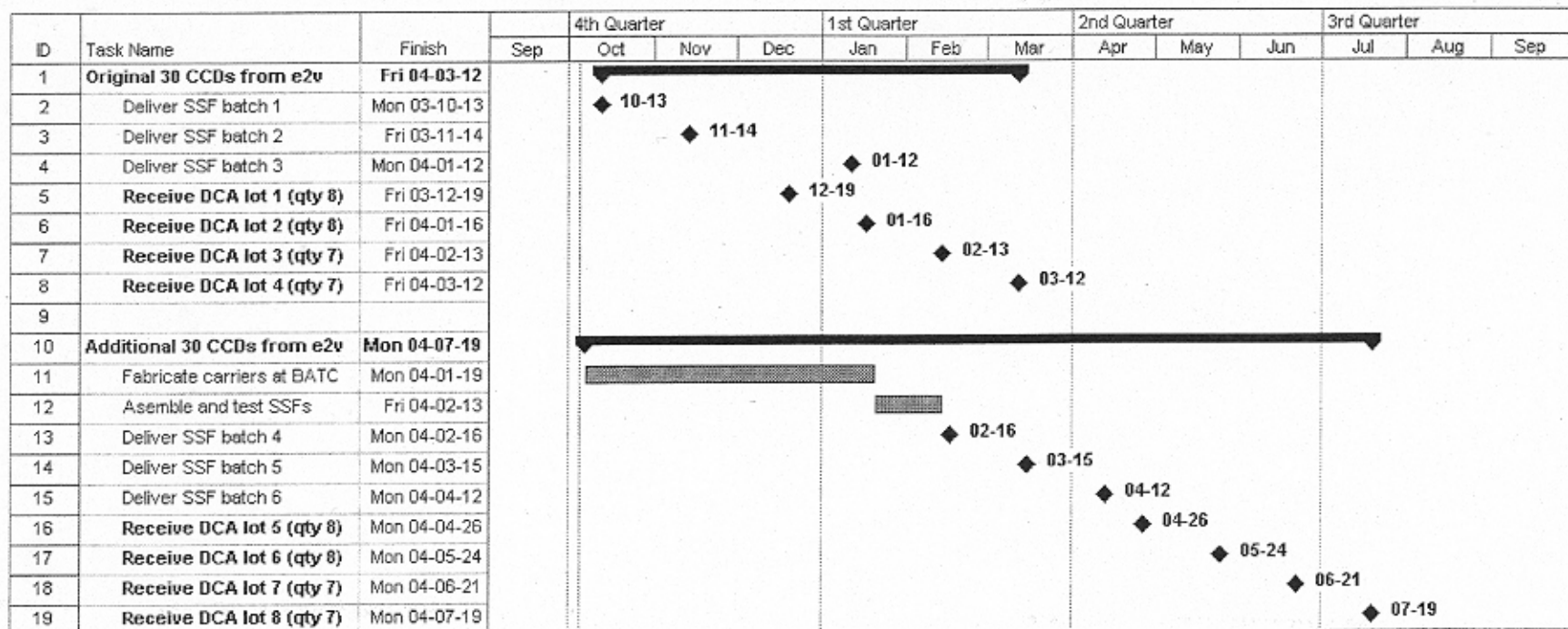


Single row Nanonics connectors are used to interface each CCD to the backside PCB

Kepler procurement results (to date)

- **At 11 months, one vendor was judged to be noncompliant and struggling.**
- **The second vendor (E2V) was awarded the full 60 device contract.**
- **So far, the second vendor is fully compliant and on schedule.**

- A feasible schedule shows uninterrupted delivery of approx. 8 CCDs per month
 - Final deliveries ~ July '04
 - Proposed schedule only; consistent with Engr deliveries, but must be worked with e2v



Some things I have learned (or at least thought about):

1. If two vendors are good risk mitigation at the 60-device level, then 3 or more may be a **really good idea at the 1000-device level. For CCDs, I can count at least four commercial vendors for thinned devices: E2V, STA, Fairchild, and Sarnoff. (Are there others ?)**

2. It is probably possible to come up with a design that all four above could produce. The device itself is not rocket science.

3. For any one vendor to promise to produce more than 100 devices per year after design debug is probably pushing too hard. We may be able to live with this restriction if we have enough viable participants.

Dealing with our potential vendors:

- 1. We need a *real* strawman CCD design in hand before we can seriously talk to vendors. That means format, pixel size, amplifier locations, phase count, and maximum edge losses. Then we can start an iterative process with them to come up with a final design that is compatible with as many vendor processes as possible.**
- 2. We need a well-conceived LSST-controlled packaging design to apply to all vendors. This must include both the mechanical and electronic aspects in enough detail so that the physical mating of CCDs to frames, and frames to modules, and so forth up to the full focal plane, can be seen as a whole. The Kepler model of project-supplied packaging hardware should be earnestly considered.**
- 3. Give some thought up front on what testing needs to be done by vendors and what is to be done by the project. This is not a satellite that cannot be serviced/upgraded, so don't go overboard with test requirements.**